TECHNIQUES

CAD/CAM Preparation: Techniques and Tips

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Based on technologies developed for aerospace, automotive and other precision industries, CAD/CAM ***(Computer Aided Design/ Computer Aided Manufacturing)*** now has a proven, 20-year track record in dentistry in terms of clinical performance in fit, longevity, sensitivity, strength and wear resistance. Today, dental CAD/CAM systems are being utilized to an ever-increasing extent to design and fabricate metal, alumina and ziconia frameworks as well as for the creation of stronger, better fitting and more esthetic all-ceramic anterior and posterior crowns and bridges. Of course, both dental materials and computer technology have evolved over the 20 years, making it easier and easier for dental practitioners to make their practices "metal-free" should they so desire.

What hasn't changed is the foundation for all successful dental restorations: proper preparation and precision model work. In the realm of CAD/CAM, inadequate reduction or poor preparations can sabotage all of your careful planning and any chance for a great final restorative result.

New Materials Require New Fabrication Techniques

CAD/CAM has made the use of denser metallic and ceramic materials possible in dental applications. These materials, such as Zirconia and Zirconium oxide, offer substantial improvements in the longevity and strength of dental restorations. Zirconia is a mineral that initially resembles a soft chalk after refining. In dentistry, we sinter the material to its final hardness, making it nearly impossible to cut or shape with conventional dental techniques. Even more important, the sintering process shrinks the original Zirconia material at a ratio that can only be controlled through complicated computerized calculations (it is this shrinkage that gives Zirconia its density and strength). With few exceptions, most Zirconia restorations are milled approximately 25% larger than the final desired size and shape.

CAD Technologies Demand Greater Accuracy at All Levels

Technicians are now using computers to design all aspects of a restoration on a computer screen rather than by hand, replacing traditional wax and spatula. This means everyone involved (dentist and technician) must make a slight change in the way we visualize a dental restoration, both in the lab and at the chair.

CAD technology utilizes state-of-the-art computers and laser scanners with sophisticated 3-dimensional software programs for unsurpassed accuracy and precision. However, that final accuracy and precision can only be as accurate and precise as your initial preparation. As we all know in our daily lives, computers are not very good at handling ambiguities. A computer likes clarity and will only make one of two finite choices when faced with a decision: **Yes or No; Black or White; 0 or 1.** Now, let's apply that same concept to a computer creating a digital version of a crown & bridge preparation. The computer sees a mass of 1's and 0's as it scans the "lines" of the preparation off the model. Its job is to map all those 1's and 0's into a three-dimensional, on-computer, digital version of the preparation that the technician can use as the base or foundation to design a complete restoration.

Milled, untrimmed frame following 12 hours of "hard sintering".

Mapping Accurate Margins

The challenge arises when the computer encounters what we would describe in layman's terms as a "grey area" (or an area of the margin that is not clearly defined). A technician working on a wax model can use their years of experience and judgement to overcome (or fill in) this area of the margin. A computer will only make two choices: "the margin line lies here, or the margin lies there". If part of the margin is difficult to make out with the human eye, then it will be all but impossible for the computer to map using digital technology. For example, if the margin line provided on the preparation is consistent, sharp and uniform – the computer will plot it easily and accurately (e.g., 1111111111111111). But for every place that the margin line is uneven or inconsistent, the computer will replace a "1" with a "0". The greater the number of zeros, the less chance that the accuracy and precision that all participants in the process are seeking will actually result.

Figure 1. Cross-section of coping.

Figure 2. Reverse view of coping.

Let's look at a couple of photos of actual preparations to illustrate how the computer actually "sees" the margin and what is required for optimal results. Figure 1 shows a cross-section of a coping on a preparation with a uniform, well-defined margin line resulting in a firm static fit to the restoration. Figure 2 shows the reverse side of the same coping illustrating how well it fits and the nice contours. An erratic and/or uneven margin makes duplication very difficult for the drill of the milling machine and often results in open and/or overextended margins. While it is true that CAD programs are becoming more sophisticated every day (and will try to fill in the blanks based on their programming parameters), the more information a computerized system has to fill in for itself, the less predictable the final result will be.

Figure 3. Chamfer margin.

Figure 4. Milling head.

Duplicating the Vertical Walls

Another challenge lies with digitizing the vertical walls of the preparation. The computer system must calculate the height and angle of the vertical surfaces of the restoration using much the same viewpoint, as the doctor would have while the patient is in the chair (i.e., from above at roughly a 90 degree angle). Why? Because that is how the milling head of the system approaches the case during fabrication (see Figure 4).

A preparation with a very steep axial wall means that the computer has very little information (or landmarks) with which to plot the surface area of the axial wall. The steeper the wall, the fewer the landmarks obtained and the less accurate the restoration. Preparations with a gentler angle of the axial wall (e.g., the diagram in Figure 5 shows a preparation with a tapered angle of 7 degrees) allow more landmarks to be obtained and a more predictable fit and more accurate final result!

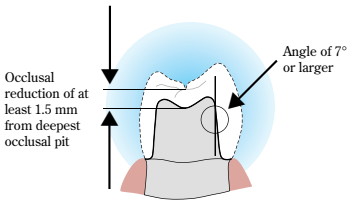

Figure 5. Preparation with tapered 7° angle.

Conclusion

If the recommended guidelines outlined here (clearances, reductions, landmarks and clear margins) are adhered to, CAD/CAM systems can provide strong, highly esthetic restorations that will seat quickly with minimal adjustment. An extra minute or two spent on the preparation (and checking that preparation) will pay off exponentially in time saved later at the try-in and insertion appointments.

Preparation Tips and Techniques

Indications:

- Anterior full-coverage crowns.
- Posterior full-coverage crowns.
- More extensive bridge substructures than possible with alternative systems.
- Implant all ceramic abutments to mask discolouration.

Contraindications:

- Knife-edge, feather-edge and/or irregular margins.
- Insufficient preparation reduction.
- Inaccurate preparations.
- Unparalleled preparations.
- Undercuts in margin areas.
- Insufficient occlusal clearance (minimum 2 mm required).
- Veneers/Inlays/Onlays.

Laboratory Requirements:

1. Thoroughly detailed prescription denoting which teeth are to be crowned, extracted and/or bridged as well as selected shade.
2. Clear and accurate upper and lower full arch impressions or study models.
3. Bite registration.
4. Include a pre-op model for all anterior cases. Include an impression of temporaries for all anterior restorations when four (or more) units are involved.

Preparation:

General:

1. As a rule, preparations for CAD/CAM must always have a precise, well-defined, clearly visible margin.
2. Margins should be sharp, but all internal features, whether positive or negative, should be rounded as with any all-ceramic. These smoothly flowing angles result in the most accurate scan and the most accurate fit. Avoid sharp angles and undercuts.
3. Maintain an even reduction of anatomical form.
4. Zirconium cannot be soldered. However, the technician can often see if the bridge will draw at the beginning of the design and discuss possible preparation adjustments before the case is milled.

Preparation Techniques and Tips:

1. Before starting treatment (and prior to administering anaesthetic), use an ultra thin articulating film to record the bite – while the patient is still seated upright. This allows the occlusion to be verified on articulated models at a later stage to achieve more accurate restorative fit.
2. CAD/CAM restorations can be fabricated on a pronounced, distinct 360° chamfer or shoulder-type preparation. Clear margins are a prerequisite for an accurate restoration. Do not create a lip on the margin. *NOTES: We do not recommend feather-edge margins as they do not provide adequate reduction for porcelain build-up. The outer edge of trough (or gutter) shoulders may not be detected when scanned. Tangential preparation and shoulders with a bevel are not suitable because both preparation forms result in margins that drain off too thinly and may result in facture of the final restoration.*
3. Cylindrical diamond instruments with a rounded tip are especially suitable for the shoulder preparation with a rounded axio-cervical angle. Use of rotary instruments with an average grit size of 30 µm is recommended for finishing the preparation.
4. Ideally, to get an optimal scanning process, the preparation should be conical with a minimum vertical side angle of 7°. (See Diagram 3)
5. Ensure that a parallel path of insertion is maintained.
6. All preparation walls and preparation borders must be visible from the vertical viewpoint for optimal scanning.
7. In principle, preparation is very similar to that employed for PFM restorations. A 1.5 – 2.0 mm reduction is required at the incisal/occlusal and buccal/lingual surfaces (depending on whether it is an anterior or posterior application) with the margins prepared for a deep chamfer/shoulder with approximately 0.8 – 1.5 mm gingival/cervical reduction. ***(See Diagram 1 – Anterior Preparation and Diagram 2 – Posterior Preparation on back page).***
8. These are minimum requirements. Strength will be increased with more tooth reduction (Note: opacity will be less, translucency will be better).
9. Connectors: Zirconia frameworks must have a minimum pontic connection cross-section (elliptical preferred for maximum yield strength) to prevent fatigue-related fracture over time. This ranges from 4 mm^2 (for a three unit lower anterior bridge) and 5 mm^2 (for a three unit upper anterior bridge) to 16 - 18 mm^2 for a four unit upper posterior bridge with two pontics.

Adjustment Tips:

- Avoid internal adjustment of CAD/CAM restorations. When adjustments are necessary, adjust prepped tooth.
- Porcelain sections of the restoration may be polished with conventional ceramic polishing systems.
- Avoid carbide use.

Left side of frame showing Contessa 360° butt margins ready to accept pressed Ceramic.

Right side of frame showing typical porcelain to margin used in conventional porcelain build-up.

Anterior Crown Preparation (CAD/CAM)

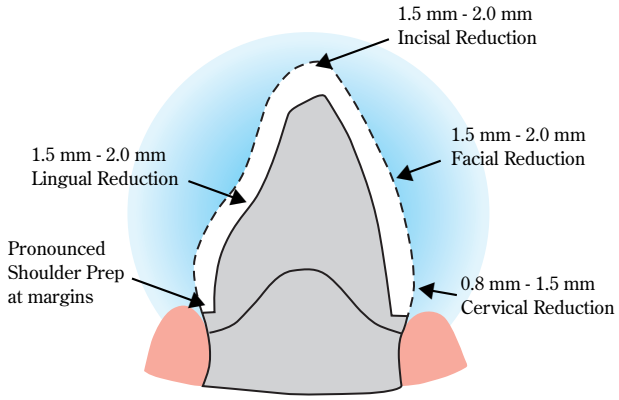

Diagram 1 – Anterior Preparation.

Posterior Crown Preparation (CAD/CAM)

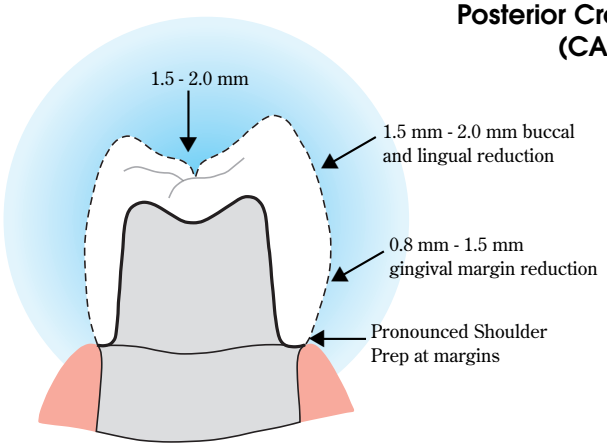

Diagram 2 – Posterior Preparation.

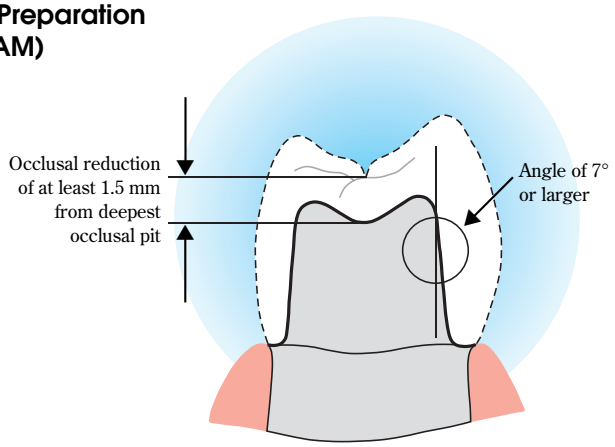

Diagram 3 – Posterior Preparation (Occlusal reduction and minimum vertical side angle).

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